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SEASONAL FLUCTUATIONS IN THE SURFACE SALINITY ALONG THE COAST OF THE SOUTHERN PART OF KALIMANTAN (BORNEO)

by

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SEASONAL FLUCTUATIONS IN THE SURFACE SALINITY ALONG THE COAST OF THE SOUTHERN PART OF KALIMANTAN (BORNEO).

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MISS SJARMILAH SJARIF.

SUMMARY

The westerly current of the Java Sea from the southeast is branched to the north, along the eastcoast of Kalimantan (Borneo) as far as Cape Mangkalihat. This current brings high saline water, over 34.0‰, and increases the salinity along the coast of the southern part of Kalimantan, working together with the decreasing rains.

In the westmonsoon, when the westward current has retreated and the easterly current from the South China Sea has developed, the northerly current along the eastcoast is replaced by a southerly current, from the Pacific. Under influence of the increasing rains and the large outflow of the rivers in the southern part of Kalimantan the salinity decreases rapidly, until a minimum value. This minimum is found irregularly during the diffferent months of the westmonsoon or the succeeding transition period. The lowest values are found in Sukadana Bay (29.0‰) and off Bandjarmasin (± 24.0‰). The further from this place, the higher the values.

The maximum salinity is found during the months September and October in accordance with the minimum rainfall. The highest values are found in the eastern part of the investigated area (34.5‰). To the west it is lower, the more it is mixed with the low-saline water of the Java Sea. The salinity in the Karimata Strait is about 33.0 to 33.5‰.

ZUSAMMENFASSUNG.

Der nach Westen führende Strom der Java See zweigt von Südosten kommend entlang der Ostküste Kalimantan (Borneo) nach Norden ab und reicht bis Kap Mangkalihat. Dieser Strom führt stark salzhaltiges Wasser, über 34.0‰ und verstärkt den Salzgehalt entlang der Küste des südlichen Teils Kalimantans noch mehr, ausserdem durch die sich vermindernden Regenfälle.

Während des Westmonsuns, wo der nach Westen führende Strom zurückweicht und der nach Osten gehende Strom sich von der Südchine-

sischen See ausbreitet, wird der nördlich verlaufende Strom entlang der Ostküste ersetzt durch einen südlich fliessenden Strom des Pacific. Unter Einfluss des sich verstärkenden Regens und der grossen Ausströmung des Flusses im südlichen Teil Kalimantans, nimmt der Salzgehalt bis zu einem Minimum schnell ab. Dieses Minimum wird ersichtlich während der verschiedenen Monate des Westmonsuns, oder der nachfolgenden Übergangsperiode. Die niedrigsten Werte sind in der Sukadana Bucht (29.0‰) und ausserhalb Bandjarmasins (± 24.0‰) zu finden. Je weiter von diesem Platz entfernt, desto höher werden die Werte.

Der Maximumgehalt ist während der Monate September und Oktober zu verzeichnen, infolge der minimalen Regenfälle. Die höchsten Werte sind im östlichen Teil gefunden worden (34.5‰). Im Westen werden sie aber niedriger, je mehr sie mit dem wenig salzhaltigen Wasser der Java See vermischt werden. Der Wert in der Karimata Strasse beträgt ungefähr 33.0 - 33.5‰.

Ichtisar.

Arus kearah barat di Laut Djawa jang berasal dari tenggara bertjabang keutara, mengalir sepandjang pantai timur Kalimantan hingga Tg. Mangkalihat. Arus ini membawa serta air jang berkadar garam tinggi, lebih dari 34.0‰ dan meninggikan kadar garam disepandjang pantai Kalimantan bagian selatan.

Pada musim barat, djika arus kearah barat berbalik dan arus kearah timur bertambah kekuatannja, arus kearah utara jang mengalir sepandjang pantai timur diganti oleh arus kearah selatan dari Samudera Pasifik. Dibawah pengaruh meningkatnja tjurah hudjan dan banjaknja pengaliran air sungai[2] di Kalimantan selatan kadar garam dengan tjepat menurun hingga mentjapai minimum. Minimum ini terdapat setjara tidak teratur dalam berbagai bulan selama musim barat atau musim peralihan berikutnja. Harga[2] minimum jang terendah didjumpai diteluk Sukadana (29.0‰) dan dimuka Bandjarmasin (± 24.0‰). Semangkin djauh dari tempat[2] tersebut semangkin tinggilah harga minimum.

Kadar garam maksimum terdapat selama bulan[2] September dan Oktober bertepatan dengan minimum tjurah hudjan. Harga maksimum jang tertinggi terdapat dibagian timur (34.5‰). Semakin kebarat harga itu semakin turun, karena lebih banjak bertjampur dengan air jang berkadar garam rendah dari Laut Djawa. Kadar garam diselat Karimata kira[2] 33.0‰ sampai 33.5‰.

From former publications it is clear that the pattern of surface salinities in the Indonesian waters is a complex one, influenced by the semi-

annual changing monsoonwinds as well as by the outflow of the big rivers. This last influence is especially conspicuous in the offings of Sumatra and Kalimantan (Borneo). The big rivers discharging into the seas surrounding these islands have an enormous effect on the surface salinity. During the westmonsoon broad belts of water of low salinity surround these islands. VEEN (1951) already pointed out that to determine the extent to which the surface salinity is influenced by the prevailing monsoon a large amount of data for a number of years is required. Since VEEN (1949) our Institute has continued in collecting surface salinity data.

HARDENBERG and SOERIAATMADJA (1953) have shown the importance of the fluctuations in the surface salinity in connection with the lajang (Decapterus spec.) fisheries in the western part of the Java Sea. According to the Biological Division of the Seafisheries Service at Djakarta, one of the most important fishes off the coast of the southern part of Kalimantan is the kembung (Rastrelliger spec.). Two species are found, i.e. Rastrelliger kanagurta mainly along the southeast coast and Rastrelliger neglectus at the westcoast (Sukadana Bay) during October - April. The optimum salinity for R. kanagurta is about $31.0^0/_{00}$ to $33.0^0/_{00}$, and for R. negletus somewhat lower. In how much the appearance and disappearance of Rastrelliger is influenced by the changing salinity is still to be investigated. We hope that this paper will contribute to practical fisheries.

This paper is based on all the data available at our Institute, which were assembled by Captain K. M. VAN WEEL in 1917 and 1918, a few scattered data from Snellius and Dana (1929 - 1930); from 1937 onwards the Institute for Marine Research at Djakarta collected data in the Java Sea, from Sunda Strait to the southern part of Macassar Strait. These activities were stopped in December 1941 at the outbreak of war. In 1949 VEEN, then Oceanographer of the Marine Institute at Djakarta, started an extensive survey of surface salinities over the whole area of the Indonesian Archipelago. This survey was made possible through the courtesy and voluntary co-operation of all Captains and Officers of private navigation companies, the government Navigation Service and Lighthouse-keepers. The procedure of collecting and analysing watersamples has been described extensively by VEEN (1951 and 1953) and SOERIAATMADJA (1956).

The area surveyed (Fig. 1) includes the region between 1°S and 5°S, extending from the South China Sea 108°E to the Strait of Macassar 118°E, occupying the southeastern outlets of the South China Sea, the whole northern part of the Java Sea and the southwestern outlets of the Macassar Strait. This area is very much influenced by the large drainage of the big rivers in the Southern part of Kalimantan. It belongs to the Sundaflat and

is a very shallow sea with a gradual slope from the coast to the centre, with a maximum depth of about 50 meters, except at several places of the far eastern end at the border of the Sundaflat, where greater depths occur.

The number of available data amounts to 16.768 up to December 1958. The area surveyed is divided into 28 one-degree squares, although the frequency of observation data is not the same (tb. 1 and 2). Some squares contain more than 1000 observations, and others less than 100 (S. 0315 only 12 and therefore no analysis is made for this area). The mean surface salinity value for each square is derived from the monthly means of each year.

From fig. 2 and 3, which represent isopleths of the surface salinities in the northern part of the Java Sea, we may see, that the annual range in the eastern part is larger than in the western part. This phenomenon was also noted by SOERIAATMADJA (1956) for the southern part. Only in the latter the lowest value for the West monsoon is found in the western part, being higher eastwards. This is not the case in the northern part. The minimum salinity decreases towards 115°E and afterwards increases again. In the western part the annual range is from 31.5$^0/_{00}$ to 33.1$^0/_{00}$, at 115°E from 29.5$^0/_{00}$ to 34,1$^0/_{00}$ and in the most eastern part from 31.0$^0/_{00}$ to 34.5$^0/_{00}$. According to BERLAGE, VEEN and SOERIAATMADJA, the Java sea is influenced by two different monsoon currents in concordance with the seasons. One from the east with high salinity and another from the west with low salinity. The low salinity in the west monsoon is not only caused by the eastward current from the South China Sea, but also by the large drainage of the big rivers in the southern part of Kalimantan. The influence of these rivers is very conspicuous in the northern part, compared with the southern part of the Java Sea, especially off Bandjarmasin, where the salinity can drop below 24$^0/_{00}$. This low salinity can still be noted farther south in square S. 0514.

According to the Eastern Archipelago Pilot (1949) the horizontal movement of the water along the south coast of Kalimantan is a mixture of tidal streams and monsoon currents. In the northwest monsoon a predominating eastgoing stream may be expected, and in the southeast monsoon a westgoing stream. That these monsoon currents and tidal streams influence the salinity, has been described above.

In the Macassar Strait a southerly or south-south-westerly current is generally observed in the open part throughout the year. But in the great bight southward of Cape Mangkalihat it is stated that there is a constant northerly current along the Kalimantan coast; just outside this current the general southgoing current may sometimes be running at a consider-

able rate. During the southeast monsoon, from April to October, the current runs northward along the whole of the eastcoast of Kalimantan as far as Cape Mangkalihat, where it turns southeastward and southward to join the general southgoing current. This current is probably caused by the westgoing monsoon current of the Java sea, striking the east coast of Kalimantan and thus tending to pile up the water on the western side of Macassar Strait. In the northwest monsoon the northerly coastal current is not present. In the southern part of the Macassar Strait the direction of the southgoing current is influenced by the prevailling monsoon. In June - September it is southwesterly, and so on emergence passes into the westgoing current of the Java sea. In November - March it becomes southeasterly and so passes into the eastgoing current of the Java and Flores Sea.

A. *The transition period March - April - May.*

During this monsoon-change, along the southcoast of Kalimantan, between 3°S and 4°S. and 108°E - 118°E a sharp decline in salinity occurs from west to east, which is caused by the eastgoing current from the South China Sea, and the salinity decreases the more it is mixed with river water of the southern part of Kalimantan. Between 108°E and 110°E, which comprises open sea and is a part of Karimata Strait, the salinity is about 31.5‰ - 32.5‰. From 110°E to 115°E., the area with low salinity approaches the coast more and more. In the Bay off Bandjarmasin the salinity is the lowest, but here a pronounced increase in salinity caused by the beginning westerly current in the period March - May already occurs (fig. 4a), while in other places the salinity is about the same and has an increase or decrease of 1‰ maximum. The salinity (30.0‰ - 31.5‰) in the Strait of Macassar is lower than in Karimata Strait. In June the westerly current spreads further westward and the salinity increases up to 111°E.

South of this area, from 4°S to 5°S. (fig. 5a) between 108°E and 115°E., there is also a decline to the east, but not so sharp. More eastward the salinity increases again. West of 113°E the salinity range is only about ½‰, while to the east the salinity increases clearly, although in the most eastern part (31.0‰ - 31.5‰) it is still lower than in the western part (31.7‰ - 32.2‰).

At the westcoast from 1°S to 5°S the salinity increases from Sukadana Bay southward, the further it is from the coast. Except in Sukadana Bay (30.0‰ - 31.5‰) the salinity in the westcoast has only a range of ½‰ maximum, varying from 31.5‰ - 32.0‰ or 32.0‰ - 32.5‰ during these months (fig. 6a).

On the eastcoast, from 1°S to 5°S., the salinity decreases from north to south (fig. 7a), in accordance with the southward current. This current gradually mixing with coastal water, becomes less saline. In May the current along the east coast of Kalimantan turns to the north and meets the southerly current in S. 0216. In June there is already a reverse course of the salinity, being higher in the south than in the north. Here the salinity range is much higher than in the westcoast.

B. *The full eastmonsoon June - July - August.*

The horizontal differences in salinity become lesser and there is a distinct increase from month to month, up to September. The westerly current has fully developed, and now we have a reverse condition, the salinity being higher in the east than in the west, with the lowest concentration moved to the west. In September it is found in the area S. 0312. This is due to the strong current with high saline water from the southeast, which pushes the low saline water off Bandjarmasin to the west. The horizontal difference is not only caused by the monsoon current, but also by the river drainage. This is evident in September, when the outflow of the rivers is much less, and the lowest concentration in the middle drops only $1^0/_{00}$ (fig. 4b).

Like the northern area, in the south there is also a distinct increase up to September, caused by the westward current and the lesser rain. That lesser rains effect the salinity is clearly illustrated in the disappearing of the lowest concentration at square S. 0414. The westerly current looses its high concentration when it spreads to the west, the more it is mixed with the low saline water of the Java Sea. Under influence of this current the salinity in the east is higher than in the west. (fig. 5b).

In June and July the salinity at the westcoast is about the same, slightly lower than in the monsoonchange (between $31.0^0/_{00}$ and $32.0^0/_{00}$), and gradually decreasing from the south to Sukadana Bay. (fig. 6b). In August the salinity increases in the whole area, up to September, except in Sukadana Bay, where it drops at the start of the rains.

The northerly current along the eastcoast of Kalimantan, as is indicated by the Eastern Archipelago Pilot, now fully developed, can be seen clearly in the decrease from south to north. This current with high salinity as a branch of the westerly current of the Java Sea originates from the Flores Sea, is piled up on the western side of Macassar Strait and flows to the north, loosing its high saline character the more it is mixed with coastal water. That the salinity off Balikpapan is slightly higher than south of

it, is assumed to be caused by the mixture of higher saline water from the south-south-westerly current. (fig. 7b).

C. *The transition period September - October - November.*

With the beginning rains and the retreat of the westerly current, the water becomes less saline, the lowest concentration moves back to S. 0314, and the decline in salinity to this area becomes steeper. The salinity still decreases until December (fig. 4c).

The highest salinity is generally found in the month September, when the westward current reaches its maximum advance, and the rainfall its minimum, except in the squares S. 0412 to S. 0415, where higher salinities are found in October. In November the salinity decreases clearly, and in December the great outflow of rivers off Bandjarmasin is shown again in the lower salinity particularly at S. 0414. (fig. 5c).

The picture in the west coast is nearly the same as in the dry season, only the decrease towards the coast is steeper, and the salinity drops a little from month to month, more pronouced in the south due to the retreating westerly current (fig. 6c).

In September and October the salinity along the southeast coast has its highest concentration. The northerly current reaches its maximum advance and starts to retreat. The southerly current sets in. The salinity decreases in the whole area by the increasing rains, and in December there is a reverse condition, the salinity being higher in the north than in the south. At S. 0416 the influence of the retreating northerly current is still felt, the salinity being slightly higher than in S. 0316 (fig. 7c).

D. *The full westmonsoon December - January - February.*

During the wet season there is no definite decrease in salinity from month to month, except in the eastern part, where the salinity decreases until February and in S. 0314 until March. For the lowest concentration, no regularity could be found in the different months of the westmonsoon or the following transition period (fig. 4d). This is also clear from the sinusoides (fig. 9). In February when the eastward current has fully developed the salinity in the east is lower than in the west, and the decline towards S. 0314 is very steep.

South of this area the salinity decreases slightly in the western part, the lowest salinity being found in March. In the east, like in the case above, the decrease is more distinct with a minimum in February. Here also the salinity in the months January and February is higher in the west than in the east (fig. 5d).

That the westerly current has retreated and the easterly one influences the region, is also clear from the decrease in salinity from S. 0209 - S. 0409, whereby Sukadana Bay contents coastal water with lower concentration (fig. 6d). The seasonal fluctuations in the southwest is not great, which also can be seen from the sinusoides (fig. 8, 9 and 10). It is a characteristic of the whole South China Sea. The mean annual salinity of the Java Sea, south of Sukadana Bay is higher, e.g. from Sukadana Bay southward 30,7‰, 32.1‰, 32.3‰ and 32.2‰.

Now the southerly current is fully developed. The more southern, the lower the salinity. That the area of S. 0416 has a much lower concentration, although it is a part of the open sea, is also explained by the low saline water of the eastward current (fig. 7d). On the whole, the salinity in this region is decreasing from month to month until January by the increasing rains and the outflow of rivers. Compared with the westcoast the annual range in the eastcoast is higher, about 3.5‰ to 4.5‰ and in the west about 1.5‰ to 2.0‰ caused by the high saline water of the South Pacific, which flows straight into the Macassar Strait. The situation of the annual means of salinity is reversed, showing a decrease from north (Balikpapan) to south, i.e. 32.4‰; 32.1‰; 32.0‰ and 32.0‰.

Fig. 8, 9 and 10 illustrate the annual variation in the salinity of every square, while the dotted lines show the annual means. In all parts along the coast of the southern part of Kalimantan there is a decrease of the annual means from the sea towards the coast.

Compared with the southern part of the Java Sea (SOERIAATMADJA 1956), there is no gradual increase in the annual means from west to east in the northern part, because here the influence of riverwater is much stronger. The annual means between 3°S and 4°S shows a decrease running from west to 115°E.. which is, as mentioned above, caused by the outflow of rivers. Nearer to the east the annual means increase again (fig. 9). Between 4°S and 5°S. there is indeed a slight increase to the east, but from 112°E. to 115°E. it decreases clearly, to increase again afterwards (fig. 10).

Like in the southern part the increase in salinity in the eastern section starts in the period March - May, when the eastgoing current gradually decreases and finally is replaced by a reverse current, which means an invasion of the oceanwater into the Java Sea. This waterbody with high salinity over 34.0‰ reaches its maximum advance at the end of the succeeding full eastmonsoon (September) at 113°E. between 4°S and 5°S., which is more to the east than in the area between 5°S and 6°S [112°E], and does not reach the area between 3°S and 4°S.. The advance of this ocean water is

in accordance with the salinity chart by VEEN (1953), but too far to the west if compared with WYRTKY's September salinity chart, which is only composed of data of one year (1955).

The highest salinity, like said before, is found in all cases in the month September. Only in some squares the salinity in the month October is as high. The gradual displacement of the highest concentration from September in the eastern section to November in the western section in the southern part of the Java Sea is not found here. And the sudden drop in salinity in December, found in the southern part, is found in November in the northern part.

As previously stated, besides the influence of the monsooncurrents, the influence of precipitation is important. Therefore several diagrams (fig. 11 and 12) about the annual variation in rainfall in the coastal area of the southern part of Kalimantan are presented, derived from BERLAGE's and more recent data, which were kindly placed at our disposal by the Meteorological Institute at Djakarta. Although this was worked out only for 9 squares, a strong correlation between yearly salinity variation and rainfall is observed. This correlation, however, is not found between the absolute values. From June to December, during the full eastmonsoon and the succeeding monsoonchange, there is a distinct decrease in rainfall to a minimum in September - October and afterwards an increase to December, with the reverse condition regarding the surface salinity, except in square S. 0109, where the minimum rainfall and maximum salinity are found in July -August. In the wet season and the next monsoonchange there is not such a strong correlation between the maximum rainfall and minimum salinity in the same month. The fluctuations in this period are irregular, both as to rainfall and salinity, although there is some correlation, e.g. the maximum rainfall is found in December and March (S. 0311), in May (S. 0312) or in January and March (S. 0116) and the according minimum salinities in January and April, in May, and in February and April.

ACKNOWLEDGEMENTS.

Acknowledgement is given to the Officers of the several private navigation companies and to Officers of the government Navigation Services, who operate regularly along the coast of the southern part of Kalimantan (Borneo), for their voluntary cooperation in taking water samples.

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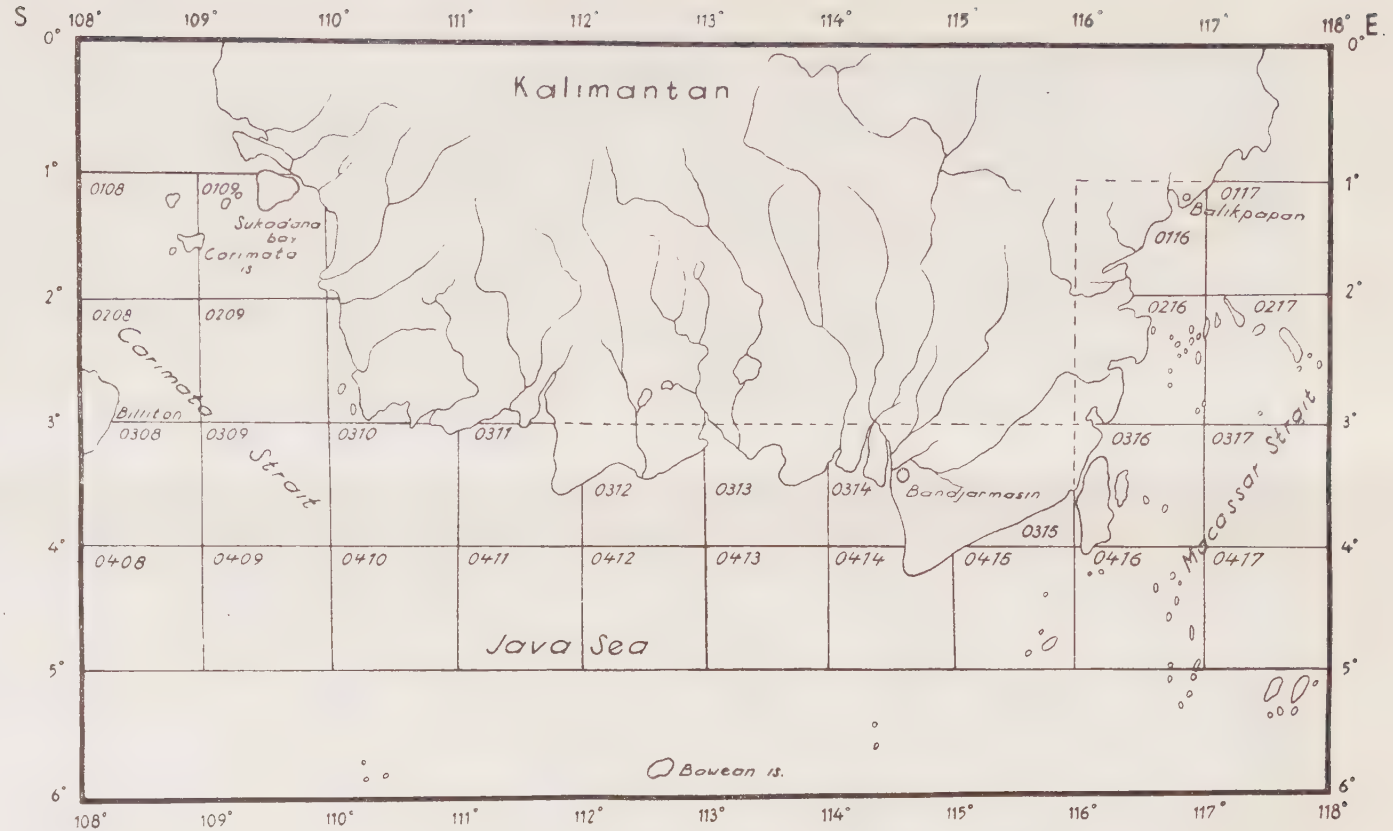

Fig. 1. Area under investigation with 1° square

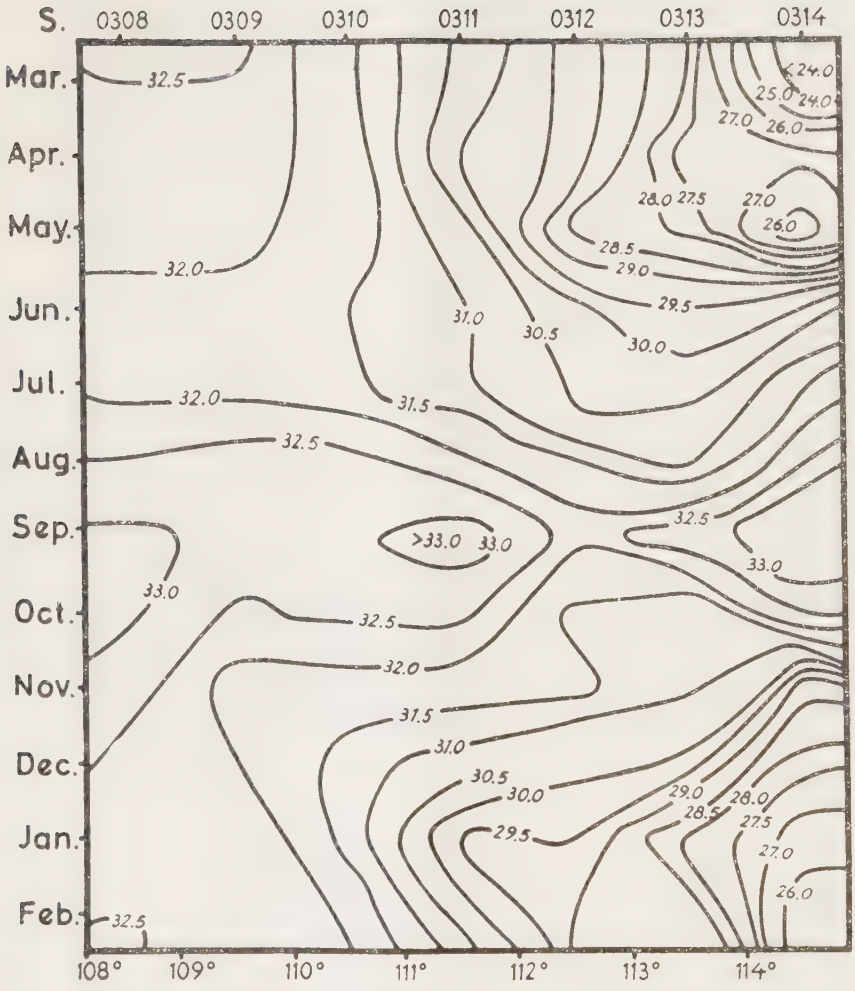

Fig. 2. Isopleths of surface salinity along the south coast of Kalimantan

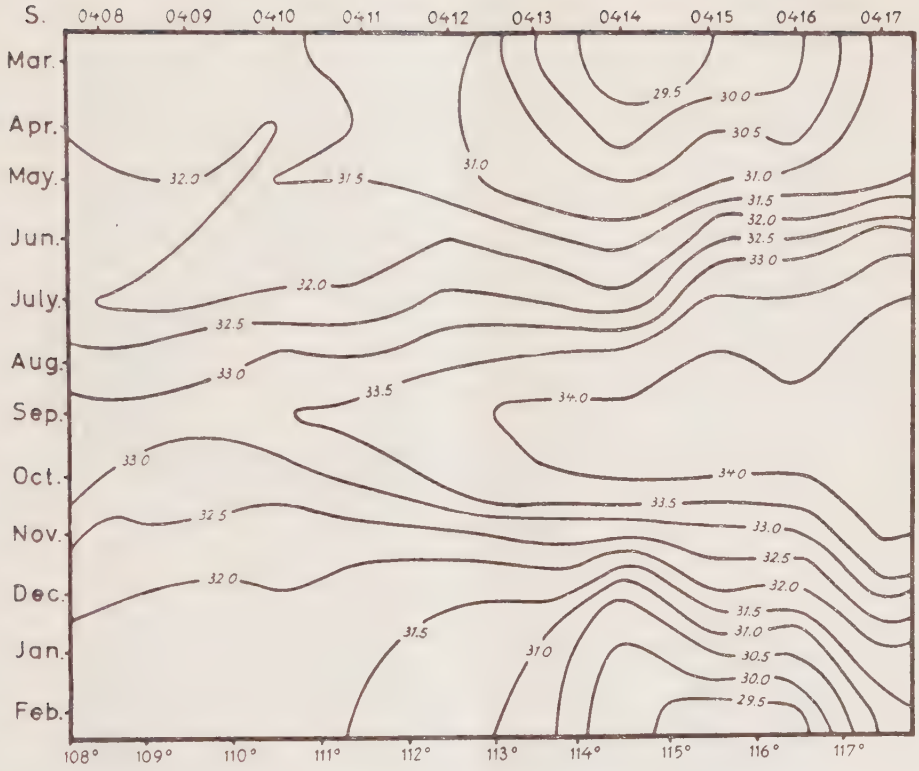

Fig. 3. Isopleths of surface salinity along the south coast of Kalimantan

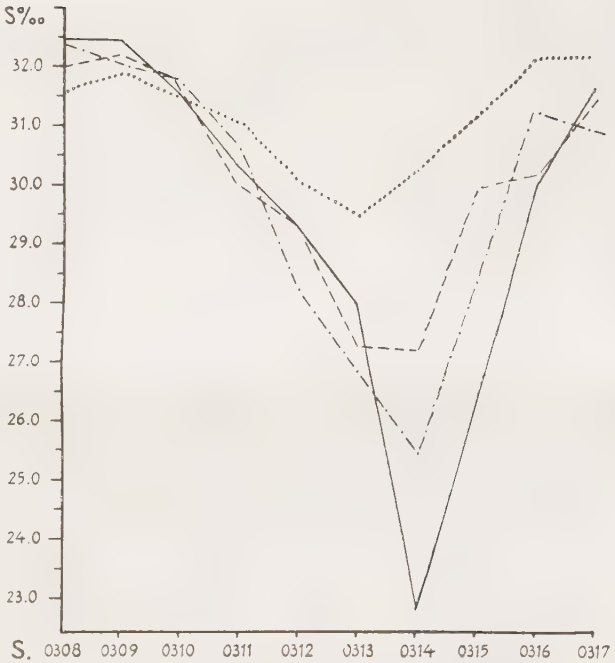

Fig. 4.a. Salinities in 1° squares S.0308 to S.0317 during the months March (——), April (----), May (-·-·-), and June (°°°°°).

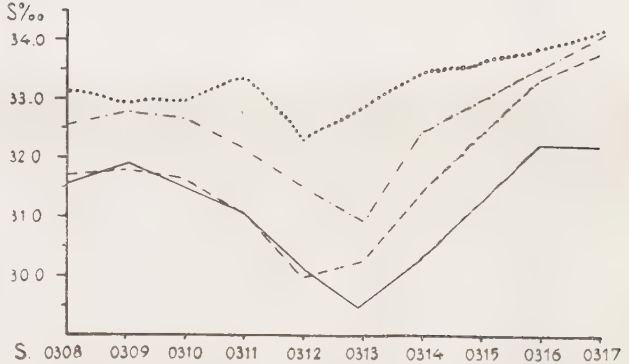

Fig. 4.b. Salinities in 1° squares S.0308 to S.0317 during the months June (——), July (----), August (-·-·-), and September (°°°°).

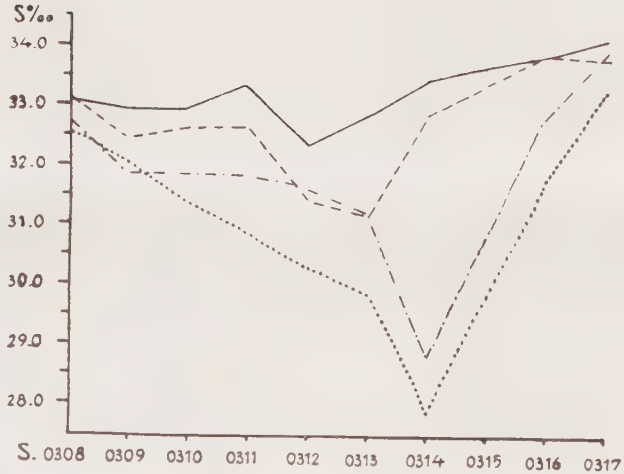

Fig.4.c. Salinities in 1° squares S.0308 to S.0317 during the months September (——), October (----), November (-·-·-), and December (°°°°°).

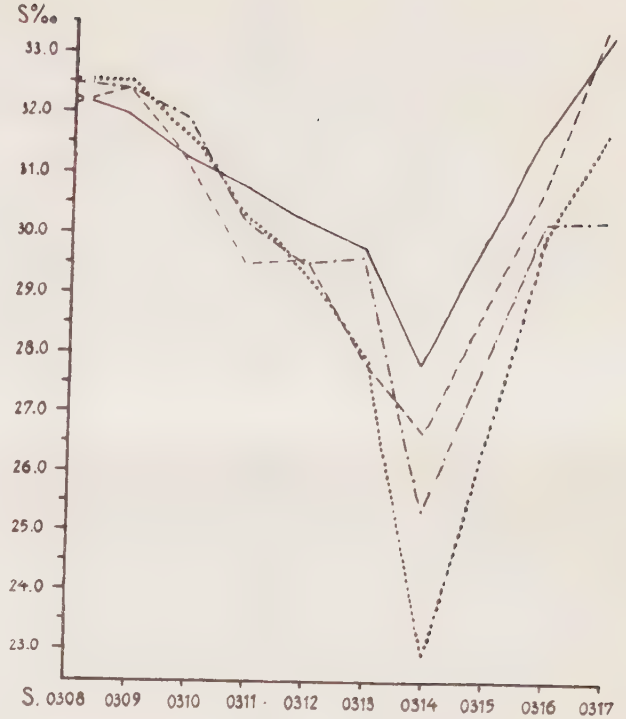

Fig.4.d. Salinities in 1° squares S.0308 to S.0317 during the months December (——), January (----), February (-·-·-), and March (°°°°).

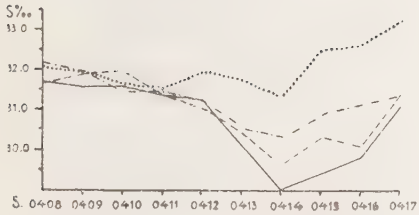

Fig.5.a. Salinities in 1° squares S.0408 to S.0417 during the months March (——), April (----), May (-·-·-), and June (·····).

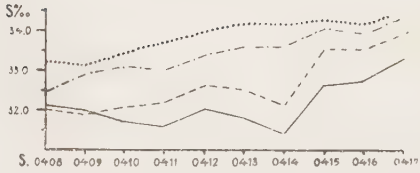

Fig.5.b. Salinities in 1° sguares S.0408 to S.0417 during the months June (——), July (----), August (-·-·-), and September (·····)

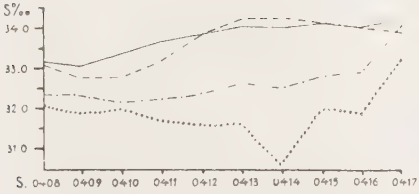

Fig.5.c. Salinities in 1° squares S.0408 to S.0417 during the months September (——), October (----), November (-·-·-), and December (·····).

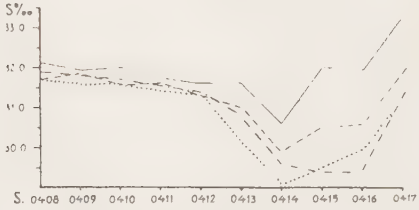

Fig.5.d. Salinities in 1° squares S.0408 to S.0417 during the months December (——), January (----), February (-·-·-), and March (·····).

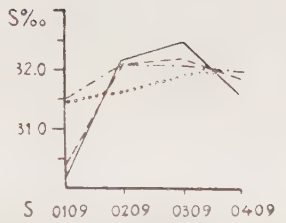

Fig. 6.a. Salinities in 1° squares S.0109 to S.0409 during the months March (——), April (---), May (-·-·-), and June (····).

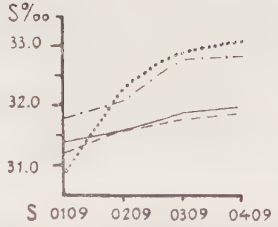

Fig.6.b. Salinities in 1° squares S.0109 to S.0409 during the months June (——), July (----), Aug. (-·-·-), and Sept. (····).

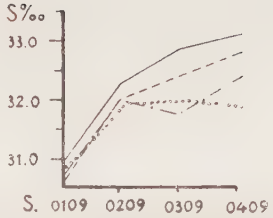

Fig.6.c. Salinities in 1° squares S.0109 to S.0409 during the months Sept. (——), Oct. (---), November (-·-·-), and Dec. (····).

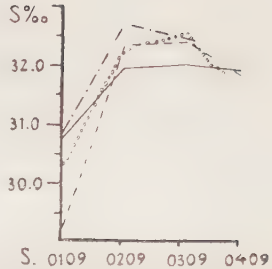

Fig.6.d. Salinities in 1° squares S.0109 to S.0409 during the months Dec. (——), Jan. (---), Febr. (-·-·-), and March (····).

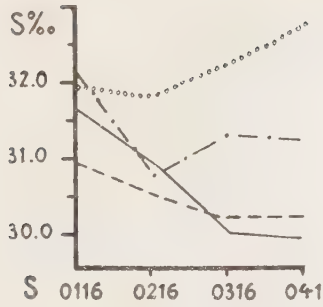

Fig.7.a. Salinities in 1° squares S.0116 to S.0416 during the months March(—),April (----), May (-·-·-), and June (°°°°).

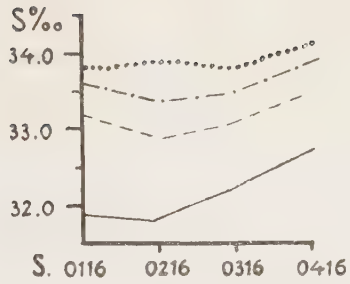

Fig.7.b. Salinities in 1° squares S.0116 to S.0416 during the months June(—), July (----), Aug. (-·-·-), and Sept.(°°°°).

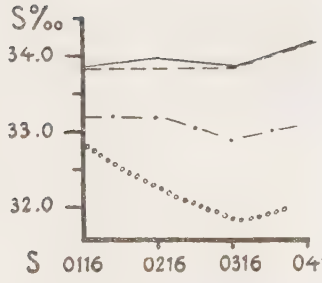

Fig.7.c. Salinities in 1° squares S.0116 to S.0416 during the months Sept.(—),Oct. (----), Nov. (-·-·-), and Dec (°°°°).

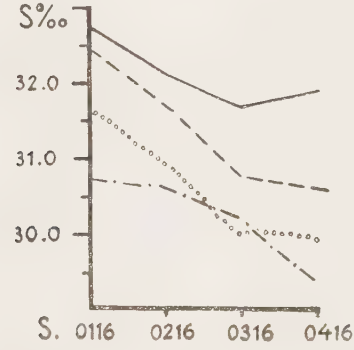

Fig.7.d. Salinities in 1° squares S.0116 to S.0416 during the months Dec.(—), Jan. (----), Febr.(-·-·-), and March(°°°°).

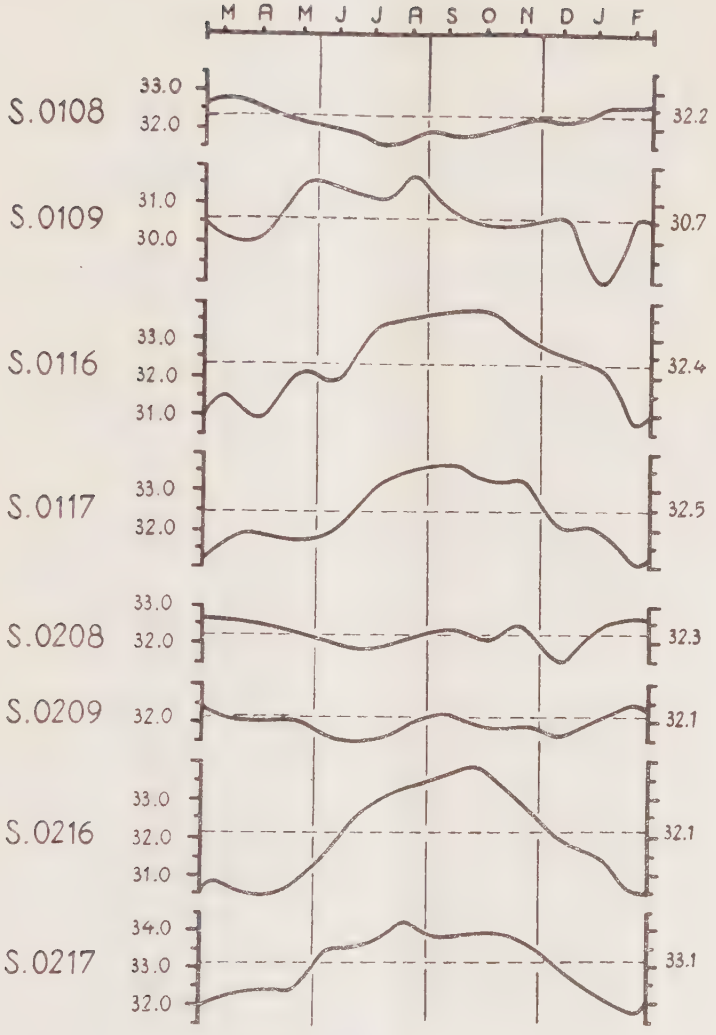

Fig.8. The annual variation and the annual mean of salinity for every 1° square

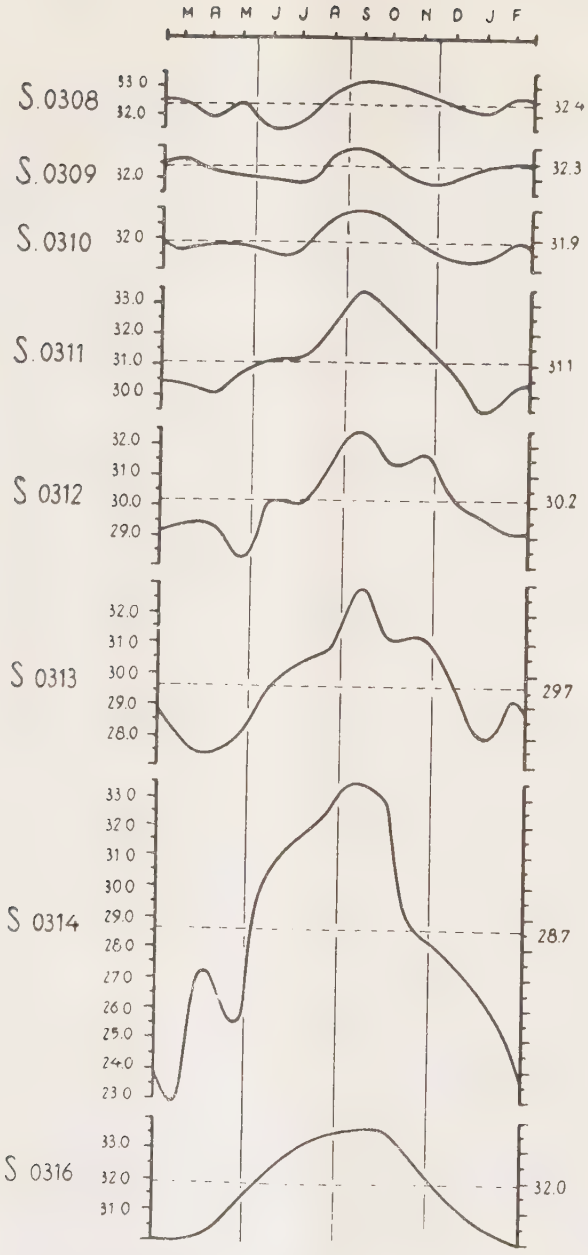

Fig.9. The annual variation and the annual mean of salinity for every 1° square

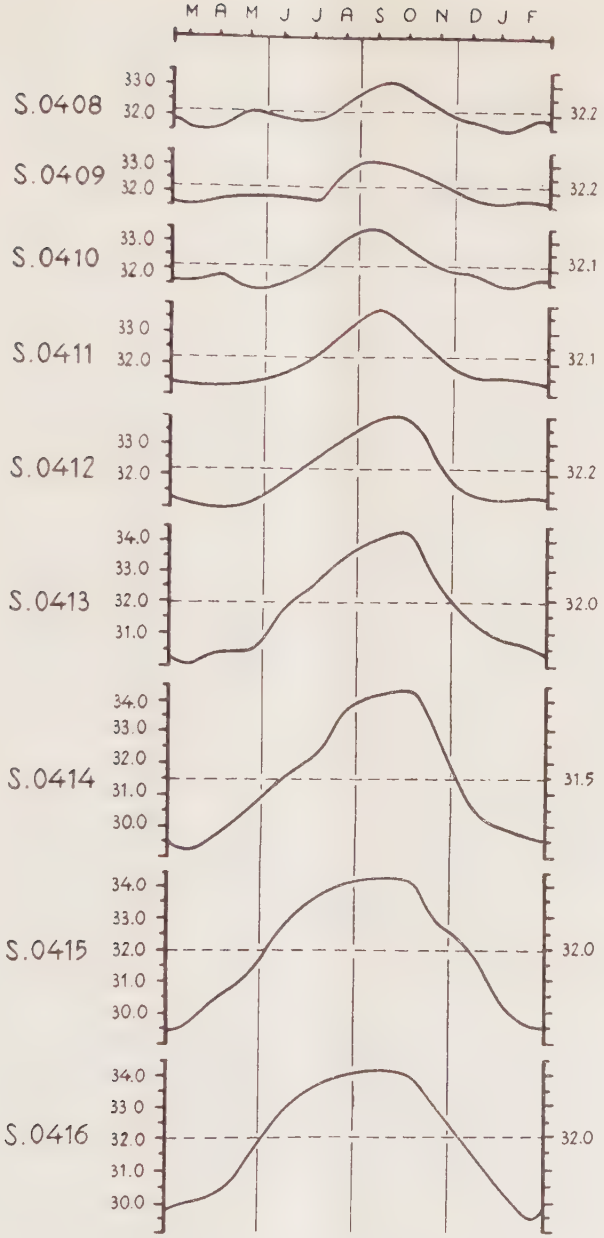

Fig.10. The annual variation and the annual mean of salinity for every 1° square

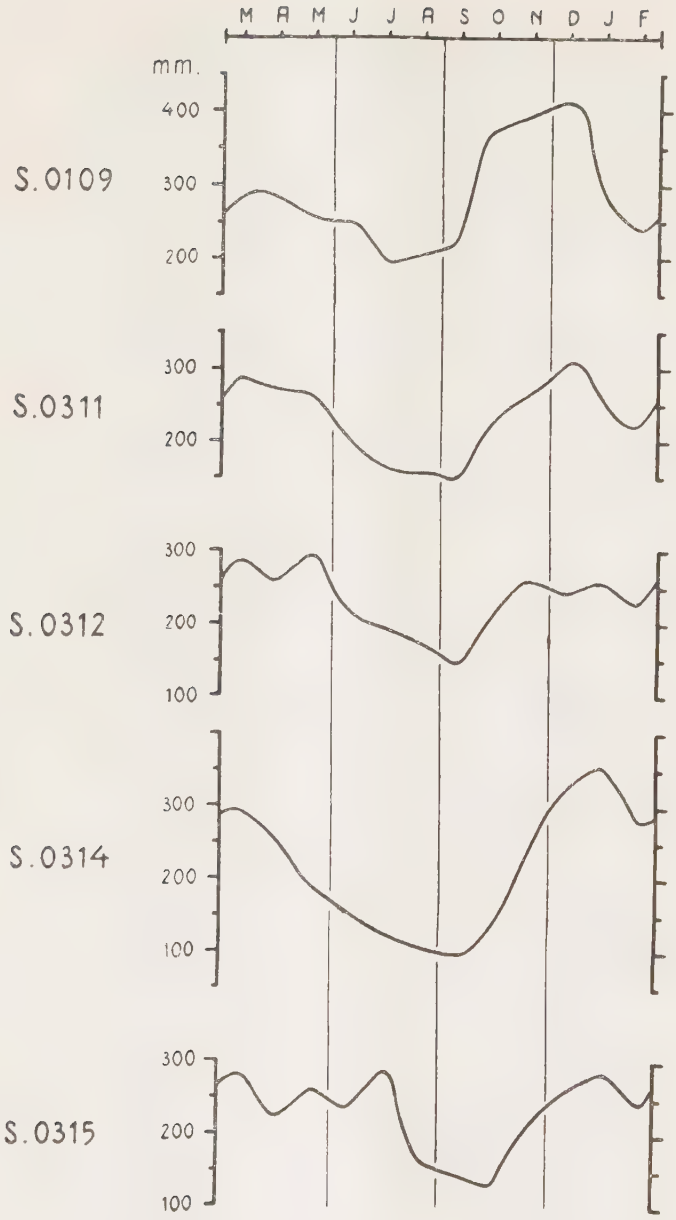

Fig. 11. Rainfall in the coastal region of the Southern part of Kalimantan

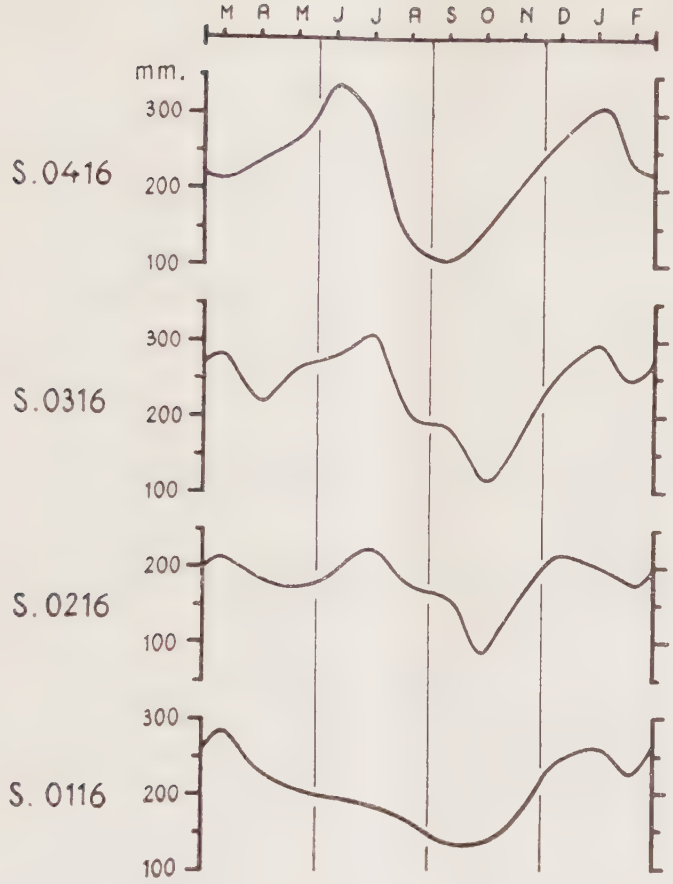

Fig. 12. Rainfall in the coastal region of the Southern part of Kalimantan

TABLE 1. NUMBER OF OBSERVATIONS PER SQUARE-DEGREE FOR EACH MONTH.

Latitude - South:

Square Number	March	April	May	June	July	August	September	October	November	December	January	February	Total Number
0108	151	139	112	109	137	152	130	111	138	105	139	118	1.541
0109	10	4	10	9	3	8	11	7	8	9	10	12	101
0116	33	37	26	42	41	37	37	45	37	40	33	38	446
0117	61	73	54	78	73	86	105	77	69	70	65	71	882
0208	30	27	36	18	30	26	20	21	29	21	33	32	323
0209	77	67	85	69	74	87	76	61	66	63	68	75	868
0216	67	59	50	85	80	99	78	101	89	64	80	56	908
0217	25	13	18	17	21	13	23	21	8	7	14	9	189
0308	8	22	19	8	10	16	7	5	14	19	14	38	180
0309	72	75	83	73	76	84	59	41	66	64	73	81	847
0310	42	45	48	39	35	33	41	34	39	23	25	31	435
0311	21	43	28	20	32	25	26	29	29	19	23	19	314
0312	45	33	37	27	43	33	35	35	36	34	36	33	427
0313	57	42	34	35	29	51	29	35	37	35	37	35	456
0314	27	29	32	33	24	42	34	26	35	29	15	17	343
0315	—	2	—	—	—	2	—	1	2	—	4	1	12
0316	87	85	79	102	96	120	106	100	96	89	82	35	1.077
0317	5	1	5	7	2	3	6	10	1	3	1	2	46
0408	39	27	35	29	29	34	24	34	32	19	20	50	372
0409	49	40	42	29	33	38	21	34	29	33	36	50	434
0410	93	78	87	63	73	87	66	67	74	69	112	79	948
0411	86	72	92	73	80	104	69	75	79	74	32	61	897
0412	66	75	70	52	59	68	55	60	64	60	49	51	729
0413	92	94	111	81	79	99	75	114	96	78	160	89	1.168
0414	94	95	104	80	66	81	80	72	114	76	74	59	995
0415	50	44	52	51	46	63	63	68	74	53	61	38	663
0416	92	73	82	88	81	106	93	98	96	95	94	69	1.067
0417	14	9	9	12	10	9	11	5	8	6	4	3	100

TABLE 2. MEAN SALINITY PER SQUARE DEGREE FOR EACH MONTH.

Latitude - South:

Square Number	March	April	May	June	July	August	September	October	November	December	January	February
0108	32,7	32,5	32,2	32,0	31,7	31,9	31,8	32,0	32,2	32,2	32,6	32,6
0109	30,1	30,2	31,5	31,4	31,2	31,8	30,9	30,5	30,6	30,7	29,0	30,7
0116	31,6	30,9	32,1	31,9	33,2	33,6	33,8	33,8	33,1	32,7	32,4	30,7
0117	31,6	31,8	31,6	32,0	33,1	33,6	33,8	33,4	33,3	32,1	32,1	31,0
0208	32,6	32,5	32,3	32,1	31,9	32,2	32,4	32,2	32,5	31,6	32,3	32,7
0209	32,2	32,1	32,1	31,6	31,6	32,1	32,3	32,0	32,0	31,9	32,3	32,6
0216	30,9	30,5	30,8	31,8	32,9	33,4	33,9	33,8	33,1	32,1	31,7	30,6
0217	32,2	32,5	32,4	33,5	33,7	34,2	33,8	34,0	33,9	33,2	32,4	31,9
0308	32,5	32,0	32,4	31,6	31,7	32,6	33,1	33,1	32,7	32,3	32,1	32,5
0309	32,5	32,2	32,1	31,9	31,8	32,8	32,9	32,4	31,8	32,0	32,4	32,4
0310	31,6	31,8	31,8	31,5	31,6	32,7	32,9	32,6	31,8	31,3	31,3	31,9
0311	30,3	30,0	30,7	31,1	31,1	32,2	33,3	32,6	31,8	30,8	29,5	30,2
0312	29,3	29,3	28,3	30,1	30,0	31,5	32,3	31,4	31,6	30,2	29,6	29,0
0313	28,0	27,3	27,9	29,5	30,3	30,9	32,8	31,1	31,2	29,8	27,9	29,1
0314	22,9	27,2	25,6	30,3	31,5	32,4	33,4	32,8	28,7	27,8	26,7	25,3
0315	—	30,0	—	—	—	33,8	—	32,5	31,1	—	28,4	30,6
0316	30,0	30,2	31,3	32,2	33,1	33,5	33,8	33,8	32,8	31,7	30,8	30,2
0317	31,7	31,4	31,0	32,2	33,7	34,0	34,1	33,8	33,9	33,2	33,9	30,2
0408	31,7	31,7	32,2	32,1	32,0	32,6	33,2	33,1	32,4	32,1	31,7	31,9
0409	31,6	31,9	32,0	32,0	31,9	32,9	33,1	32,8	32,4	31,9	31,8	31,8
0410	31,6	32,0	31,5	31,7	32,1	33,1	33,4	32,8	32,2	32,0	31,5	31,7
0411	31,4	31,4	31,5	31,6	32,2	33,0	33,7	33,2	32,3	31,7	31,6	31,5
0412	31,3	31,1	31,3	32,0	32,6	33,4	33,9	33,9	32,4	31,6	31,3	31,4
0413	30,1	30,5	30,6	31,8	32,5	33,6	34,1	34,3	32,7	31,6	31,0	30,8
0414	29,1	29,7	30,4	31,4	32,1	33,6	34,1	34,3	32,6	30,6	29,9	29,6
0415	29,5	30,4	31,0	32,6	33,5	34,0	34,2	34,2	32,9	32,9	30,5	29,4
0416	29,9	30,2	31,2	32,7	33,5	33,9	34,1	34,1	33,0	31,9	30,6	29,4
0417	31,2	31,4	31,5	33,3	33,9	34,3	34,3	34,0	34,2	33,3	31,9	31,3

OCEANOGRAPHIC STATION LIST 1957

Oceanographic stations obtained by research vessel SAMUDERA in October-November 1957 in the Malacca Strait and the southern part of the South China Sea.

Station 67. 28 October 1957 11.45h
0° 18′ S. 104° 05′ E.
Depth: 37 m. Wind: N. 1-2

m	t	S	0_2
0	30.3	27.99	—
5	—	27.99	4.38
10	29.60	27.99	4.59
15	29.58	27.99	4.47
20	29.61	27.99	4.34
30	29.57	27.99	4.35
35	29.56	28.01	4.39

Station 68. 28 October 1957 16.15h
0° 20′ 7″ N. 104° 12′ 5″ E.
Depth: 46 m. Wind: NE. 2

m	t	S	0_2
0	29.7	29.65	—
5	29.87	29.61	4.48
10	29.72	29.79	4.43
20	29.68	30.01	4.27
30	29.68	30.08	4.24
35	29.67	30.12	4.27
40	29.66	30.19	4.21

Station 69. 28 October 1957 18.20h
0° 33′ 3″ N. 104° 21′ 0″ E.
Depth: 102 m. Wind: NE 3-4

m	t	S	0_2
0	29.5	31.53	—
10	29.53	31.83	4.36
20	29.52	31.91	4.40
30	29.52	31.96	4.39
40	29.52	32.09	4.34
50	29.50	32.10	4.32
60	29.48	32.10	4.37
70	29.48	32.10	4.29
80	29.49	32.18	4.09
90	29.48	32.18	4.24

Station 70. 1 November 1957 09.20h
2° 20′ N. 101° 53′ 0″ E.
Depth: 43 m. Wind. NNW 1-2

m	t	S	0_2
0	29.5	28.28	—
5	29.87	28.26	4.38
10	29.80	28.62	4.34
20	29.76	28.78	4.28
30	29.76	28.78	4.25
35	29.76	28.77	4.27
40	29.72	28.77	4.14

Station 71. 1 November 1957 11.35h
2° 28′ N. 101° 33′ E.
Depth: 75 m. Wind: NNW 1-2

m	t	S	0_2
0	29.9	28.78	—
10	29.73	28.75	4.55
20	29.70	28.75	4.40
30	29.70	28.80	4.34
40	29.70	28.82	4.33
50	29.71	28.82	4.31
60	29.71	28.86	4.24
70	29.71	28.89	4.29

Station 72. 1 November 1957 14.40h
2° 43′ N. 101° 12′ E.
Depth: 53 m. Wind: NW 2.

m	t	S	0_2
0	30.0	29.05	—
10	30.00	29.02	4.42
20	29.86	29.09	4.56
30	29.86	29.09	4.41
40	29.86	29.09	4.37
50	29.80	29.18	4.37

Station 73. 1 November 1957 19.45h
3° 04′ N. 100° 44′ E.
Depth: 78 m. Wind: NW 2.

m	t	S	0_2
0	29.8	29.45	—
10	29.99	29.42	4.42
20	29.91	30.46	4.41
30	29.70	31.67	4.43
40	29.66	32.07	4.41
50	29.66	32.18	3.33
60	29.64	32.18	3.17
75	29.60	32.23	3.04

Station 74. 1 November 1957 22. 00h
3° 32′ N. 100° 36′ E.
Depth: 49 m. Wind: NW 2.

m	t	S	O_2
0	29.7	29.70	—
10	29.80	29.79	4.52
20	29.78	30.90	4.65
30	29.74	31.58	3.42
40	29.68	31.91	3.13
45	29.60	32.27	3.02

Station 75. 2 November 1957 03.00h
4° 04′ N. 100° 19′ E.
Depth: 55 m. Wind: NW. 1-2

m	t	S	O_2
0	29.6	—	—
10	30.00	30.86	4.55
20	29.82	32.14	4.02
30	29.56	32.18	4.15
40	29.48	32.29	4.18
50	29.38	32.36	—

Station 76. 2 November 1957 05.40h
4° 31′ N. 100° 11′ E.
Depth: 51 m. Wind: NW. 1-2

m	t	S	O_2
0	29.3	30.77	—
10	29.65	30.77	4.41
20	29.76	31.65	4.48
30	29.48	32.23	3.87
40	29.36	32.41	3.10
50	29.14	32.57	3.22

Station 77. 2 November 1957 08.20h
4° 59′ N. 100° 03′ E.
Depth: 51 m. Wind: NW 0-1

m	t	S	O_2
0	29.3	30.77	—
10	29.65	30.86	4.44
20	29.66	31.96	3.75
30	29.34	32.56	3.40
40	29.06	32.77	3.34
50	28.70	32.94	3.42

Station 78. 2 November 1957 10.55h
5° 22′ N. 100° 00′ E.
Depth: 42 m. Wind: NNW 1.

m	t	S	O_2
0	29.7	30.99	—
10	29.78	30.99	4.39
20	29.78	31.92	3.89
30	29.38	32.45	3.35
35	29.26	32.59	3.41
40	29.11	32.79	3.09

Station 79. 2 November 1957 13.15h
5° 06′ N. 99° 46′ E.
Depth: 62 m. Wind: SW 0-1

m	t	S	O_2
0	30.8	30.90	—
10	29.93	31.08	4.58
20	29.78	31.15	4.48
30	29.18	32.79	4.07
40	28.74	33.01	3.74
50	28.37	33.17	3.72
60	28.02	33.33	3.62

Station 80. 2 November 1957 16.55h
4° 50′ N. 99° 34′ E.
Depth: 63 m. Wind: SW 1-2

m	t	S	O_2
0	30.4	31.31	—
10	29.97	31.40	4.49
20	29.65	32.52	4.33
30	29.23	32.81	4.21
40	28.86	33.24	4.37
50	28.03	33.26	3.77
60	27.96	33.28	3.81

Station 81. 2 November 1957 18.20h
4° 34′ N. 99° 19′ E.
Depth: 78 m. Wind: SW 0-1

m	t	S	O_2
0	29.9	31.22	—
10	29.93	31.29	4.46
20	29.63	32.34	4.24
30	28.80	33.01	4.29
40	28.20	33.22	3.68
50	28.06	33.31	3.96
60	27.75	33.35	3.55
75	27.68	33.40	3.49

Station 82. 2 November 1957 20.40h
4° 20′ N. 99° 07′ E.
Depth: 52 m. Wind: SW. 0-1

m	t	S	O_2
0	29.4	31.55	—
10	29.75	31.58	4.54
20	29.58	32.38	4.27

30	28.26	33.13	4.27
40	28.03	33.33	3.86
50	27.88	33.40	3.41

Station 83. 2 November 1957 24.00h
4° 05′ N. 98° 54′ E.
Depth: 32 m. Wind: 0

m	t	S	O_2
0	29.2	31.06	—
5	29.48	31.04	4.63
10	29.38	31.11	4.76
20	29.36	32.03	4.12
30	29.12	32.86	3.77

Station 84. 5 November 1957 00.05h
3° 52′ N. 99° 20′ E.
Depth: 53 m. Wind: SE 0-1

m	t	S	O_2
0	29.4	30.93	—
10	29.42	31.04	4.62
20	29.38	31.55	4.31
30	29.38	31.92	4.11
40	29.26	32.38	3.81
50	29.20	32.41	3.85

Station 85. 5 November 1957 02.50h
3° 33′ N. 99° 44′ E.
Depth: 53m Wind. S. 2.

m	t	S	O_2
0	29.1	30.86	—
10	29.48	31.00	4.49
20	29.48	31.49	3.94
30	29.46	32.09	3.81
40	29.42	32.10	3.83
50	29.38	32.10	3.77

Station 86. 5 November 1957 05.45h
3° 20′ N. 100° 05′ E.
Depth: 70 m. Wind: SE 3-4

m	t	S	O_2
0	29.9	30.82	—
10	29.52	31.09	4.58
20	29.56	31.13	4.60
30	29.49	31.26	4.60
40	29.48	31.35	4.43
50	29.42	32.01	3.72
60	29.39	32.05	3.67
70	29.37	32.07	3.71

Station 87. 5 November 1957 12.40h
3° 03′ N. 100° 38′ E.
Depth: 89 m. Wind:

m	t	S	O_2
0	30.2	29.18	—
10	29.91	29.51	4.36
20	29.91	30.23	3.90
30	29.78	31.44	3.50
40	29.67	31.83	—
50	29.62	32.10	3.31
60	29.60	32.14	3.17
70	29.61	32.16	3.19
80	29.61	32.16	3.17
90	29.60	32.16	3.19

Station 88. 1 November 1957 04.45h
1° 53′ N. 102° 20′ E.
Depth: 58 m. Wind: NW. 1.

m	t	S	O_2
0	29.2	28.62	—
10	29.53	28.64	4.28
20	29.50	28.78	4.44
30	29.50	28.89	4.40
40	29.52	29.09	4.32
50	29.46	29.09	4.32
55	29.36	29.09	4.33

Station 89. 1 November 1957 00.10h
1° 38′ N. 102° 51′ E.
Depth: 47 m. Wind: NNW 1-2

m	t	S	O_2
0	29.5	30.03	—
10	29.88	30.07	4.49
20	29.66	30.19	4.51
30	29.43	30.35	4.31
40	29.36	30.34	4.33
45	29.23	30.41	—

Station 90. 31 October 1957 20.00h
1° 11′ N. 103° 28′ E.
Depth: 42 m. Wind: NW. 2-3

m	t	S	O_2
0	29.8	28.91	—
10	29.73	29.09	4.39
20	29.26	31.09	4.24
30	29.24	31.67	4.37
40	29.26	31.71	4.36

Station 91. 29 October 1957 21.00h
1° 15′ N. 104° 03′ E.

Depth:	65 m.	Wind: NNE 1-2	
m	t	S	0_2
0	29.1	32.66	—
10	29.31	32.77	4.40
20	29.30	32.77	4.27
30	29.28	32.77	4.21
40	29.29	32.77	4.22
50	29.29	—	4.25
60	29.28	32.81	4.26

Station 92. 6 November 1957 20.15h
1° 12′ N. 104° 50′ E.

Depth:	36 m.	Wind: E 1.	
m	t	S	0_2
0	29.3	32.10	—
10	29.54	32.47	4.54
20	29.50	32.56	4.47
30	29.46	32.63	4.49
35	29.40	32.66	4.31

Station 93. 6 November 1957. 23.40h
1° 02′ N. 105° 14′ E.

Depth:	51 m.	Wind: E. 0-1.	
m	t	S	0_2
0	29.0	32.56	—
10	29.40	32.74	4.50
20	29.39	32.72	4.53
30	29.41	33.87	4.49
40	29.41	—	4.41
50	29.34	33.87	4.45

Station 94. 7 November 1957 05.50h
0° 55′ N. 106° 07′ E.

Depth:	53 m.	Wind: SE. 0-1	
m	t	S	0_2
0	29.0	32.72	—
10	29.22	32.81	4.51
20	29.25	32.92	4.48
30	29.06	32.92	4.33
40	29.06	33.06	4.37
50	29.00	33.06	4.33

Station 95. 7 November 1957 11.10h
0° 48′ N. 107° 03′ E.

Depth:	80 m.	Wind: SW. 1	
m	t	S	0_2
0	29.8	32.97	—
10	29.23	32.94	4.53
20	29.24	32.99	4.51
30	29.09	33.12	4.42
40	28.75	33.26	4.37
50	28.72	33.35	4.21
60	27.16	33.46	3.87
70	26.36	33.66	3.51
80	26.20	33.71	3.43

Station 96. 7 November 1957 16.10h
0° 32′ N. 107° 45′ E.

Depth:	33 m.	Wind: SE 1-2.	
m	t	S	0_2
0	29.8	32.70	—
5	29.91	32.74	4.45
10	29.30	32.75	4.56
15	29.05	33.01	4.54
20	28.66	33.08	4.45
25	28.63	33.15	4.38
30	28.58	33.15	4.38

Station 97. 7 November 1957 21.30h
0° 16′ N. 108° 32′ E.

Depth:	41 m.	Wind: SE 3-4.	
m	t	S	0_2
0	29.3	30.99	—
5	29.87	31.53	4.44
10	29.50	32.70	4.47
15	29.40	32.83	4.40
20	29.26	32.90	—
30	29.16	32.92	4.37
40	29.16	32.92	4.37

Station 98. 8 November 1957 00.10h
0° 10′ N. 108° 54′ E.

Depth:	28 m.	Wind: NE 2-3	
m	t	S	0_2
0	29.4	27.48	—
5	30.20	29.45	4.64
10	29.48	32.36	3.97
15	29.32	32.61	3.78
20	29.26	32.63	3.72
25	29.20	32.63	3.66